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ABSTRACT

The eye movements/fixations of 20 college students reading video displays of texts were monitored to determine how readers fixate a word that is linguistically and contextually redundant and whether readers use less visual information when perceiving these highly redundant words. The texts were manipulated so that a target noun was paired with adjectives presumed to be either high or low in contextual probability (redundancy). A particular type of spelling error also was introduced into the target noun. Similar percentages for fixating the target noun were found in both the high and low redundancy conditions: but the subjects did spend more time fixating the target noun in the low redundancy condition. On the average, subjects spent more time fixating the noun when it had the substitution error in the high redundancy condition than in the correct spelling condition. The effect of the spelling error was even more pronounced in the low redundancy condition. Since the most striking feature of the data is that differences between high/low redundancy conditions were very small, it appears that contextual influence on eye movement patterns was slight, raising doubts about the popular notion that interword context influences reading behavior. (RL)

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The Effects of Context on the Visual Perception
of Words in Reading¹

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This paper will present some of the data which were collected in connection with an experiment concerned with the role of meaningful and grammatical context on the perception of words in reading.

It is well documented that the visual system can identify stimuli faster and more accurately when the stimuli are familiar rather than novel (e.g., see Miller, Bruner & Postman, 1954), when the stimuli are typical of a category rather than atypical (e.g., see Rosch, 1973), and when the stimuli appear in appropriate context rather than in inappropriate context or out of context (e.g., see Biederman, 1972). Based on these robust findings, most theoretical approaches to perception stress the interaction of sensory and contextual information in the recognition process (e.g., see Neisser, 1967, 1976; Morton, 1969, 1970).

The experiment described here was motivated primarily by the fact that readers make use of the semantic and syntactic relations that exist among the words of connected discourse (Gibson, Tenney & Sharabany, 1971; Levin & Kaplan, 1970), and by the rather consistent finding in perception research that linguistic context can aid in word recognition (Tulving & Gold, 1963; Morton, 1964; Tulving, Mandler & Bauml, 1964).

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About fifteen years ago, several studies demonstrated the effect of context on word perception. In the typical procedure, subjects were tachistoscopically presented single words with and without prior context in an identification task. The context consisted of incomplete sentences for which the exposed words served as completions. The completion words were of either high or low probability with respect to the fragment, or were of appropriate or inappropriate congruence with respect to the fragment. For example, consider the sentence fragment THE CUP WAS PLACED ON THE, and the words SAUCER and SHELF. SAUCER is a highly probable response when one is asked to complete the sentence with one word, whereas the word SHELF has a lower probability. Yet both of these responses are grammatically and logically correct. Further, consider the sentence fragment THE SKIERS WERE BURIED ALIVE BY THE SUDDEN, and the words AVALANCHE and INFLATION. AVALANCHE is a semantically appropriate and highly probable response, while INFLATION is a less probable and a less appropriate completion for the sentence fragment.

The data from this series of studies indicated that word perceptibility, as measured by Visual Duration Thresholds, was significantly greater (VDT's were lower) for high probability words than it was for low probability words. Furthermore, contextual conditions yielded lower VDT's when compared to those conditions where there was no context. Simply stated, these studies demonstrated that the more predictable a word is within a sentence, the more easily it is perceived. Morton (1964) has further shown that there is an inverse relationship between the probability of a word in the sentence and the Visual Duration Threshold for that word.

It has been hypothesized that the facilitation afforded by context results from a decreased dependency on visual detail. For example, a reader will use the available linguistic context to predict the immediate word, and thus will require fewer visual cues to perceive it. In other words, the reader may bypass some or all of the visual detail.

This type of thinking has led many theoreticians to suggest that a reader may make virtually no reference to the text's visual features if he can adequately predict the material to come next based on his knowledge of the linguistic redundancies afforded by the text (Smith, 1971; Goodman, 1970; Morton, 1964; Haber, 1976; Norman, 1969; Rumelhart, 1977; etc.).

In order to gain a better understanding of the precise nature of the interaction between contextual and visual information in the reading process, and in order to examine this interaction in a more ecologically representative design (Brunswik, 1956), the following study was undertaken.

Specifically, this study was set up to determine if readers are less likely to fixate a word if it is highly redundant, and if readers use less visual information in perceiving a word if it is highly redundant. This second question was tested by inserting an error in a word and determining its effect. As an initial step, a minimal type of error was achieved by replacing the fourth letter (the most redundant letter in the word) with its most similar letter. Such letter information would not be needed for identifying the word if it was highly constrained. Thus, this study sought to determine whether or not such an error would influence normal reading patterns.

Method

Materials

TEXT - One hundred 60-word paragraphs were constructed, each containing five lines of text, with each line being between 69 and 73 character positions in length.

Embedded in each paragraph was a 7 or 8 letter noun whose redundancy could be manipulated by changing a preceding adjective. That is to say, in a high constraint adjective-noun context, the redundancy of the noun is substantially greater than it is in the low constraint adjective-noun context. For example, consider the following adjective-noun pairs:

High Redundancy Category

battered popcorn
magnetic compass
cardigan sweater
parental guidance
compound fracture
botanical gardens
crossword puzzles

Low Redundancy Category

adequate popcorn
suitable compass
colorful sweater
valuable guidance
terrible fracture
beautiful gardens
excellent puzzles

In general, context consists of many factors that influence the probability of occurrence of a particular stimuli. When considering those factors that influence interword redundancy in short texts, three come to mind. First, there is what I will call "thematic" constraint which consists of those influences that afford the reader an opportunity to use his knowledge of the subject or topic involved in the text. Second, there are those contributions to context that arise from the structural properties of language; these are usually referred to as syntactic constraints. And thirdly, there are those influences that come from the semantic relations that the words of the text can and can not enter into.

Each of the paragraphs used in this study was constructed to take advantage of these interword constraints. A sample passage will illustrate this point.

The movie industry recently published a study which revealed a surprising fact. Since movie theaters must have buttered popcorn to serve to their patrons who wish to purchase it, the movie industry hired a sociologist to find out how many people eat popcorn. His study showed that one out of every four moviegoers buys a container of buttered popcorn.

The target noun in this paragraph is the first instance of the word POPCORN. In information theory terms, the target word contains practically no information, i.e., it is highly predictable from the preceding context. That is the same thing as saying that in this particular context the word POPCORN is highly redundant.

However, if ADEQUATE is inserted in the paragraph instead of BUTTERED, the amount of redundancy associated with POPCORN decreases. The predictability norms for the target nouns used in this study were obtained in another experiment. On the average, the target noun was given as a response over 85% of the time in the high constraint category and less than 15 % in the low constraint category. Suffice it to say that in the contexts used, the high redundancy category adjective-noun pairs yielded greater ratios of redundancy than the low redundancy category.

Errors - A particular type of spelling error was introduced into the target noun. A single letter substitution was made in each noun by changing the fourth letter to a confusable alternative (e.g., "popcorn" became

"popeorn"). This manipulation was considered to be the most minimal type of error that could be introduced into the word at the letter level.

Questions - In order to insure that the subjects read the paragraphs and understood their basic content, comprehension questions were constructed. The questions always dealt with information stated in the paragraphs that did not involve the target noun. This was done to keep the subjects from focusing on the errors. Thus, the comprehension test also served the function of defining the task as one of reading and not error detection.

Design

The design of the study from which this partial data set results was a 2 (levels of redundancy) X 5 (types of spelling errors) within subject factorial. The data reported here result from a 2 (high and low redundancy) X 2 (no error and single letter error) within subject design.

Subjects

Twenty undergraduates who were experienced with eye movement monitoring procedures were paid to participate in this study.

Procedure

The texts were displayed one line at a time on a CRT, with a new line appearing each time the subject pressed a button. The subjects read each passage while their eye movements were monitored and recorded by computer (for details of the equipment used, see McConkie, Zola, Wolve-ton & Burns, 1978).

Subjects were instructed that they would be reading a series of five line paragraphs, each dealing with a different topic. The paragraphs were presented in groups of six, each separated by a line instructing the subject to go on to the next paragraph. After each group of six paragraphs, the subjects were administered a set of the comprehension questions associated with the just-read paragraphs. Subjects were further told that there would be intentional errors in the texts, but that they were unimportant, had no bearing on the task at hand and could be ignored.

Results

The main data to be presented today are provided by the probabilities of fixating the target nouns and by the temporal characteristics of subjects' fixation behavior in regions of and surrounding the target noun. Table I, Fig. 1 and Fig. 2 summarized the results. Three initial questions have been asked of the data.

1) Did subjects fixate the target noun when it was highly predictable? In the high redundancy condition, the usefulness of the information "contained" in the target noun is minimal. Therefore, it was not known a priori whether this word would even receive a fixation since the preceding context almost completely specified the word, and since its semantic content is not critical to achieve an understanding of the passage. Table I presents the percentage of instances that the target noun was fixated under the four conditions of this study. It is clear that subjects "paused" on the target noun frequently. Note the similar percentages for fixating the target noun in both the high and low redundancy conditions. This data indicates that subjects "paused" or centered their eye on the target noun

was achieved by computing the average amount of time each subject spent in the above defined regions of and surrounding the target noun. The means of these averages are plotted in Figure 2 for the same four regions as described above. Again, the context effect can be seen in the difference between the HN and LN conditions. On the average, subjects spent 290 msec. fixating the target noun in the HN condition, and 313 msec. fixating the target noun in the LN condition.

The data reveal that mean fixation duration on the target word under high constraint conditions was 14 msec. shorter than under low constraint conditions, and that average total time spent in fixation on the target word was 23 msec. less when the redundancy was high.

3) The question of particular interest in this study concerns whether or not subjects detected the embedded error in the target nouns. Eye movement records were analyzed in several ways to determine the influence of the error.

a) The initial analysis consisted of calculating each subject's sentence reading time. The analysis revealed that seventeen of the subjects took longer to read sentences with errors embedded in the target nouns, while three took less time.

b) A further question asks where the extra reading time comes from, i.e., was additional time spent fixating the noun that contained the letter substitution error. The same analyses described for the context situation were employed for the error conditions. Figure 2 shows the effect of the error on the total time spent fixating the various regions. On the average, subjects spent 75 msec. more fixating the noun when it had the substitution

error in the High Redundancy condition. The effect was more pronounced in the Low Redundancy condition where the difference was 120 msec.

These analyses provide some information about the detection of the single letter error, but more in depth analysis are in progress and should reveal what effect the error had when it was first encountered.

Discussion

The most striking feature of the data is the fact the differences observed under the HN and LN conditions were very small. This suggests that the magnitude of the contextual influence on the eye movement patterns was slight. It is not of the magnitude suggested from the earlier Visual Duration Threshold studies. It would appear from the analyses to date that the facilitation afforded by the context amounts to a small savings in real-time fixation upon the target noun. Such a difference is not of the type suggested by a theory of reading that speaks of a decreased dependency on visual detail for highly constrained words.

The effects observed in the HE condition are also provocative for a "prediction" or "sophisticating guessing" theory of reading, for the noun in which the error was embedded is highly redundant, and the fourth letter of that word is its most redundant letter. It appears that in some very real sense the reader is encountering all the visual detail that is afforded by the text. That is to say, the reader responds to all of the visual information that is specified by the printed message.

The popular notion that interword context influences reading behavior by providing a basis for readers to make predictions about the ensuing text is called into question by the data patterns of this study.

Footnotes

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TABLE 1

PERCENT OF TIME CRITICAL WORDS FIXATED

WORD CATEGORY	NO ERROR	ERROR
PRECEDING ADJECTIVE		
HIGH REDUNDANCY	.95	.94
LOW REDUNDANCY	.96	.96
TARGET NOUN		
HIGH REDUNDANCY	.98	.96
LOW REDUNDANCY	.96	.97

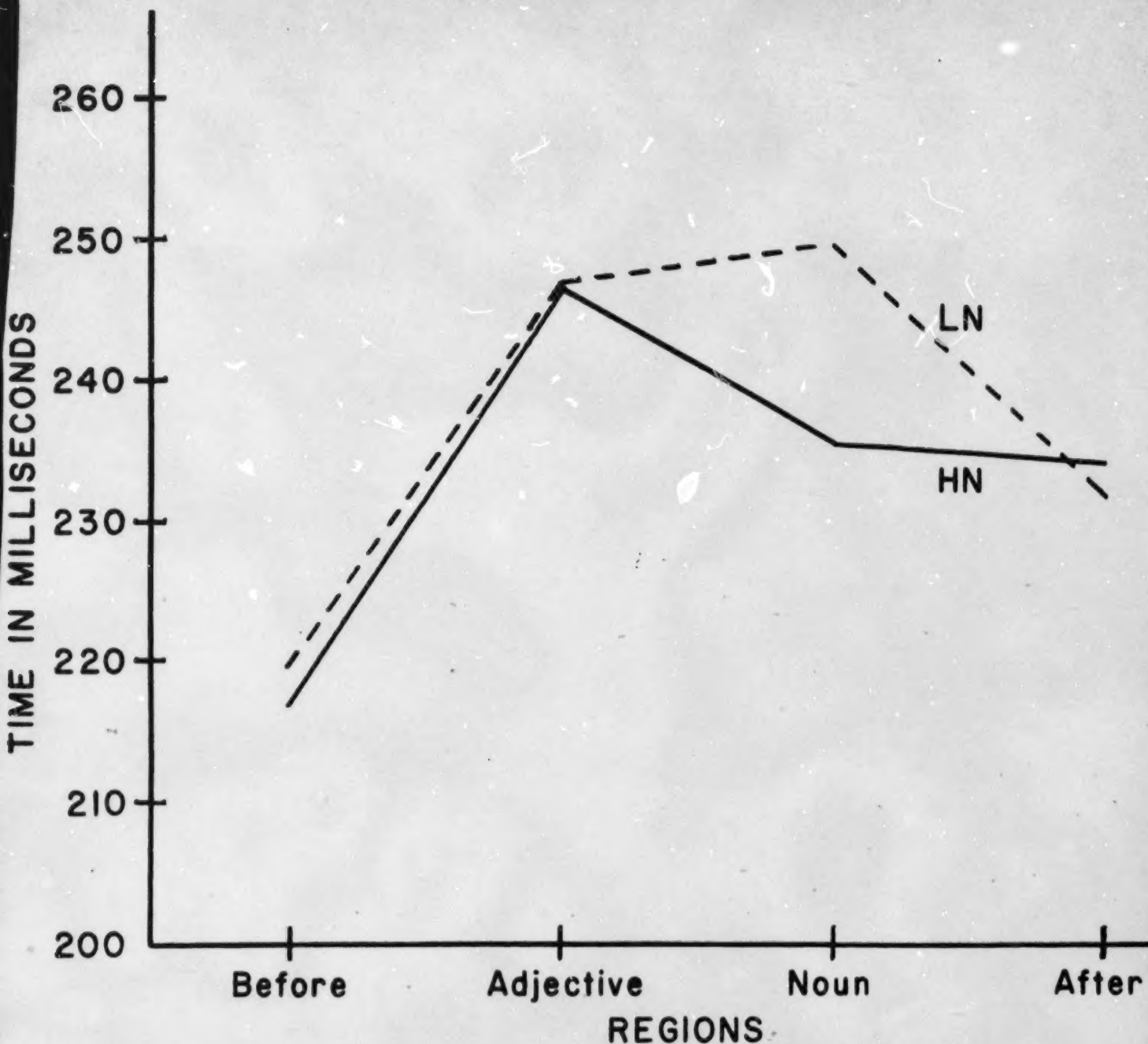


FIGURE 1: MEAN FIXATION DURATION FOR TARGETS

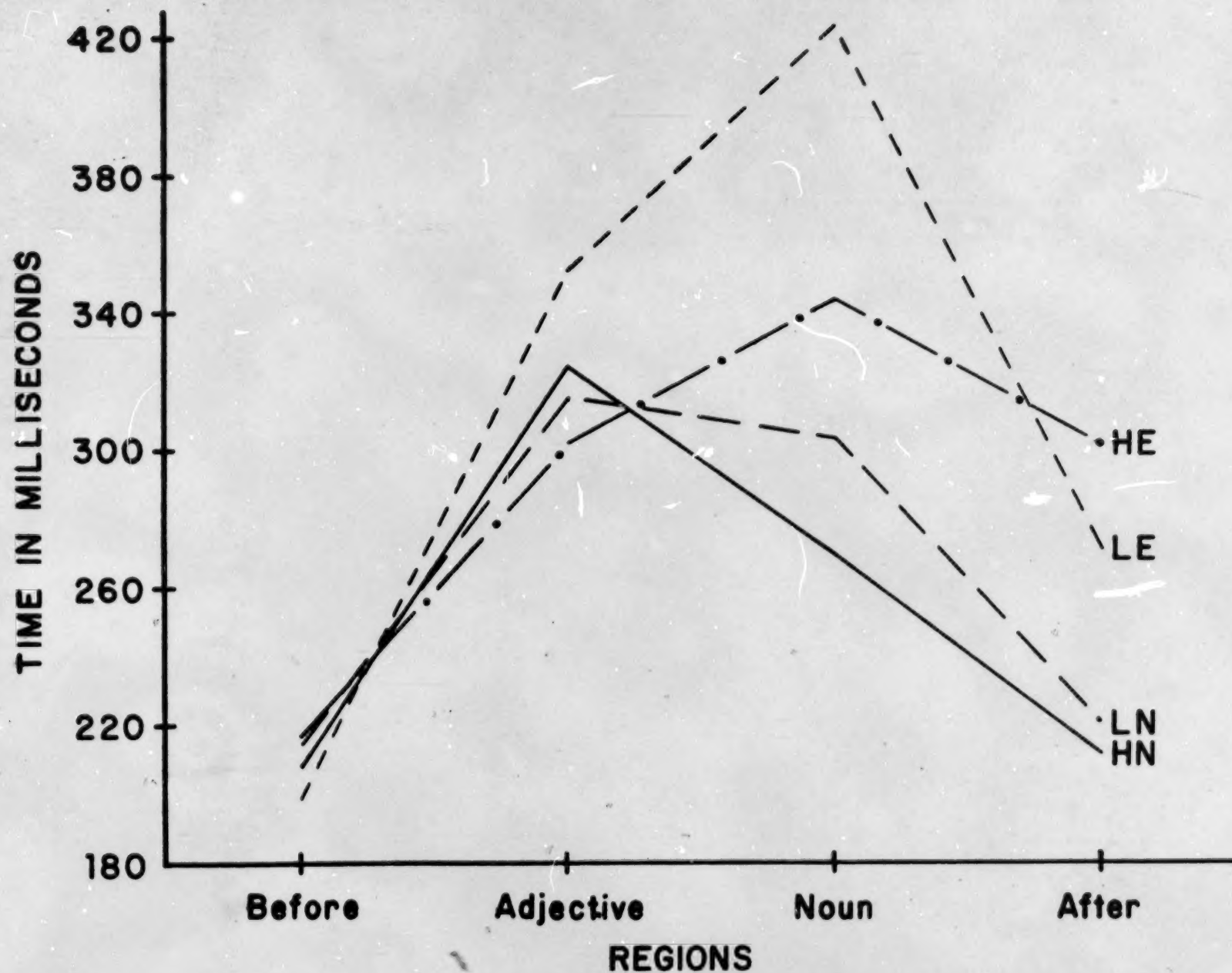


FIGURE 2: AMOUNT OF TIME SPENT FIXATING TARGETS